

WHAT IS CLAIMED IS:

1. A wireless fading-channel demodulator comprising:

a receiving-processing portion which receives and converts sub-array group analog communication signals that are received via M antenna sub-array groups, into digital input signals, multiplies the digital input signals by corresponding weighted vector elements, and sums the products for each sub-array group to generate M diversity-beamforming signals;

a signal magnitude and phase processing portion which multiplies the magnitude and phase of a representative digital input signal for each of the M sub-array groups by the corresponding one of the M diversity-beamforming signals and outputs the M products;

a final beam output portion which sums the M products output from the signal magnitude and phase processing portion and outputs a final output signal; and

a weighted vector calculation portion, wherein the weighted vector calculation portion:

calculates, from the digital input signals, a weighted vector that comprises the weighted vector elements;

selects the representative digital input signal for each sub-array group from among the digital input signals; and

calculates and outputs the magnitude and phase of the selected
representative digital input signal for each sub-array group.

2. The wireless fading-channel demodulator of claim 1, wherein the
5 receiving-converting portion comprises a plurality (M) of beamformers that each
convert analog communication signals received from one of the corresponding M
sub-array groups into the digital input signals and generate one of the M diversity
beamforming signals using the digital input signals and the corresponding
weighted vector elements;

10 and wherein each of the beamformers comprises:

analog-to-digital converters that convert L analog communication
signals received via a corresponding one of the M sub-array groups into L digital
input signals and output the L digital input signals;

15 multipliers that multiply the L digital input signals by the
corresponding weighted vector elements and that output L products; and

an adder that sums the L products that are output from the multipliers,
and outputs one of the M diversity-beamforming signals.

3. The wireless fading-channel demodulator of claim 1, wherein each of
20 the M sub-array groups comprises a plurality (L) of antennas in a sub-array that
receive wireless fading channel signals, and the spacing between the L antennas

in each sub-array group is smaller than the spacing between the M sub-array groups.

4. The wireless fading-channel demodulator of claim 1, wherein the weighted vector is calculated using the following equations:

$$u_m = [u_{m1}, u_{m2}, \dots, u_{mL}]^T$$

$$R_m = E[u_m u_m^H]$$

$$w_{m,opt} = \frac{R_m^{-1} s_{m1}}{s_{m1}^H R_m^{-1} s_{m1}}$$

where u_{mL} denotes an L^{th} digital input signal of an m^{th} sub-array group, $E[\]$ denotes the mean value, $w_{m,opt}$ denotes a weighted vector for the m^{th} sub-array group, and s_{m1} denotes a steering vector based on the direction-of-arrival of a representative digital input signal from the m^{th} sub-array group.

5. A signal receiving system for mobile communications, the system comprising:

a plurality (M) of sub-array groups, wherein each of the M sub-array groups includes a plurality (L) of antennas in a sub-array and receives wireless signals via assigned wireless channels;

a radio frequency module unit that extracts analog communication signals from the received wireless signals and outputs the extracted analog signals as sub-array group analog communication signals; and

a wireless fading-channel demodulation unit that receives and converts the sub-array group analog communication signals into digital input signals, generates M diversity-beamforming signals using the digital input signals and weighted vector elements, and outputs a final output signal by using the magnitude and phase of a representative digital input signal selected for each of the M sub-array groups and a corresponding one of the M diversity-beamforming signals.

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6. The signal receiving system of claim 5, further comprising a relay processor that processes the final output signal to relay wireless communications between mobile stations over the assigned wireless channels.

7. The signal receiving system of claim 5, further comprising a display signal output unit that processes the final output signal to output a display signal that drives a display device of a mobile station.

5 8. The signal receiving system of claim 5, wherein the wireless fading channel demodulation unit comprises:

a diversity-beamforming portion that receives and converts the sub-array group analog communication signals, which are received via M sub-array groups, into digital input signals, multiplies the digital input signals by corresponding weighted vector elements, and sums the products for each one of M sub-array groups, to generate M diversity-beamforming signals;

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a signal magnitude and phase processing portion that multiplies the magnitude and phase of a representative digital input signal for each sub-array group by the corresponding diversity-beamforming signal and outputs M products;

15 a final beam output portion that sums the M products output from the signal magnitude and phase processing portion and outputs a final output signal; and

a weighted vector calculation portion wherein the weighted vector calculation portion:

calculates, from the digital input signals, a weighted vector that comprises the weighted vector elements;

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selects one representative digital input signal for each sub-array group from among the digital input signals; and
calculates and outputs the magnitude and phase of each of the selected representative digital input signals.

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9. The signal receiving system of claim 8, wherein the diversity-beamforming portion comprises a plurality of beamformers that each convert L analog communication signals received from one of the corresponding sub-array groups into L digital input signals and generate one
10 diversity-beamforming signal using the L digital input signals and L of the weighted vector elements;

and wherein each of the beamformers comprises:

analog-to-digital (A/D) converters that convert the analog communication signals received via the corresponding sub-array groups into L
15 digital input signals and output the L digital input signals;

multipliers that multiply each of the L digital input by a corresponding one of the weighted vector elements and outputs L products; and

an adder that sums the L products that are output from the multipliers, and outputs one of the M diversity-beamforming signals.

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10. The signal receiving system of claim 5, wherein the spacing between the antennas in each sub-array group is smaller than the spacing between the sub-array groups.

5 11. A method for demodulating a signal transmitted over a wireless channel, the method comprising:

(a) receiving and converting sub-array group analog communication signals, which are received via M sub-array antenna groups, into digital input signals, multiplying the digital input signals by corresponding weighted vector elements,
10 and summing the products for each sub-array group to generate M diversity-beamforming signals;

(b) multiplying the magnitude and phase of a representative digital input signal for each sub-array group by the corresponding diversity-beamforming signal and outputting the products;

15 (c) summing all of the products obtained in step (b) to output a final output signal; and

(d) calculating, from the digital input signals, a weighted vector that comprises the weighted vector elements; selecting one representative digital input signal from among the digital input signals for each of the M sub-array groups; and
20 calculating and outputting the magnitude and phase of each of the M selected representative digital input signals.

12. The demodulation method of claim 11, wherein step (a) comprises:
converting L analog communication signals received via each one of the M
sub-array groups into L digital input signals;
multiplying each of the L digital input signals for each sub-array group by L
of the corresponding weighted vector elements and outputting L products;
summing the L products for each one of the sub-array group and outputting
one of the M diversity-beamforming signals.

13. The demodulation method of claim 11, wherein each of the M
sub-array groups comprises a plurality (L) of antennas in a sub-array, and the
spacing between the L antennas in each sub-array group is smaller than the
spacing between the M sub-array groups.

14. The demodulation method of claim 11, wherein the weighted vector
is calculated using the following equations:

$$u_m = [u_{m1}, u_{m2}, \dots, u_{mL}]^T$$

$$R_m = E[u_m u_m^H]$$

$$w_{m,opt} = \frac{R_m^{-1} s_{m1}}{s_{m1}^H R_m^{-1} s_{m1}}$$

where u_{mL} denotes an L^{th} digital input signal of an m^{th} sub-array group, $E[\]$ denotes the mean value, $w_{m,opt}$ denotes a weighted vector for the m^{th} sub-array group, and s_{m1} denotes a steering vector based on the direction-of-arrival of a representative digital input signal from the m^{th} sub-array group.

15. A signal receiving method for mobile communications, the method comprising:

- 10 (a) receiving wireless signals via a plurality (M) of antenna sub-array groups, each of which antenna groups includes a plurality (L) of antennas in a sub-array;
- (b) extracting analog communication signals from the received wireless signals and outputting the extracted analog signals as sub-array group analog communication signals; and
- 15 (c) converting the sub-array group analog communication signals into digital input signals, generating M diversity-beamforming signals from the digital input signals and weighted vector elements, and outputting a final output signal generated by multiplying the magnitude and phase of a representative digital input signal of each of the M sub-array groups by a corresponding one of the M
- 20 diversity-beamforming signals.

16. The signal receiving method of claim 15, further comprising processing the final output signal to relay wireless communications between mobile stations over the assigned wireless fading channels.

5 17. The signal receiving method of claim 15, further comprising processing the final output signal to output a display signal that drives a display device of a mobile station.

18. The signal receiving method of claim 15, wherein step (c) comprises:
10 (c1) generating the diversity-beamforming signals by multiplying the L sub-array group analog communication signals corresponding to each one of the M sub-array groups by a corresponding one of the weighted vector elements;
(c2) multiplying the magnitude and phase of a representative digital input signal for each sub-array group by the corresponding diversity-beamforming signal
15 and outputting the products;
(c3) summing all of the products to output the final output signal; and
(c4) calculating the weighted vector, comprising (M x L) weighted vector elements, from the digital input signals; selecting M representative digital input signals from among the digital input signals; and calculating the magnitude and
20 phase of each of the M selected representative digital input signals.

19. The signal receiving method of claim 18, wherein step (c1) comprises:

converting the analog communication signals into the digital input signals;

multiplying the digital input signals for each sub-array group by the

5 corresponding weighted vector elements and outputting the products; and

summing the products for each sub-array group to output one of the diversity-beamforming signals.

20. The signal receiving method of claim 15, wherein the spacing
10 between the L antennas in each of the M sub-array groups is smaller than the spacing between the sub-array groups.